Paludiculture in the UK: A paradigm shift in agricultural practice and farmers' perceptions

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SUMMARY

Shifting from drainage-based agriculture to paludiculture - that is, farming on rewetted peatlands - is one of the biggest opportunities for carbon farming and achieving net zero. By maintaining productivity without draining peat soils, paludiculture significantly reduces GHG emissions through the prevention of peat oxidation. Since emerging in the 1990s, the concept has led to several innovations in crop agronomy, product development and environmental benefits. However, despite the potential, widespread adoption remains limited. In the UK, lowland peat soils were drained for arable cultivation from the beginning of the 17th century, leading to extensive peat loss and continuing high CO_2 emissions. This long historical legacy of peatland drainage has shaped farmers' perceptions and attitudes towards peatlands, and influenced policy and legal frameworks. In this article we review the current UK policy landscape and identify the key barriers to adoption. We then use a capacity-building pyramid framework to identify the systemic factors necessary for scaling up paludiculture including policy reform, subsidy schemes, market development, enabling infrastructure, fostering knowledge exchange amongst stakeholders and, ultimately, shifting stakeholder perceptions of paludiculture.

KEY WORDS: barriers, GHG emissions, net zero, policy, wetter agriculture

INTRODUCTION

Farming in the UK is currently facing unprecedented challenges. Brexit has created new barriers and tariffs as well as increased competition arising from post-Brexit international trade deals. In addition, the agricultural support systems formerly available through the EU's Common Agricultural Policy have now been replaced in the UK by the Environmental Land Management Scheme (ELMS) and the Sustainable Farming Initiative (SFI) (Baldock & Kam 2024). These new support systems have had a troubled roll-out and continue to cause financial uncertainty amongst the farming community (NFU 2023, 2025). Nonetheless, the challenges they create are political in nature and can be altered by policy change.

Conventional farming on peat soils faces a series of more fundamental challenges, however, which cannot be addressed through policy mechanisms alone. First, peat soils subject to agricultural drainage for conventional agriculture are also, as a result, undergoing progressive ground subsidence as the peat shrinks and oxidises. Many agricultural areas on peat soils are now either below sea level or lie below the level of their regional river systems and are consequently increasingly at risk of costly flooding. Additionally, climate projections indicate that flood events are likely to become more frequent in future, both through increased rainfall and as a result of rising sea level. Furthermore, drainage-based agriculture on lowland peat soils is one of the main drivers of greenhouse gas (GHG) emissions from this soil type, with a disproportionately high contribution to climate change (Ziegler *et al.* 2021), thus exacerbating likely flood risk scenarios.

International treaties and domestic policies aimed at reducing carbon emissions are increasingly looking to the agricultural sector to make substantial reductions in its carbon emissions. Conventional farming on peat soils is thus receiving particular scrutiny. For example, the Lowland Agricultural Peat Task Force (LAPTF), appointed by the responsible UK government minister, reported that 'business as usual' was no longer an option for conventional agriculture on lowland peat soils in the UK, with all 14 of the recommendations made by that task force being accepted by the minister (Defra 2023a). Farm holdings, particularly those that contain significant areas of peat soil, are thus coming under increasing pressure on multiple fronts. If 'business as usual' is to become an increasingly non-viable option for peat

soils, are any financially viable alternatives open to farmers of such soils or must all forms of agriculture cease on these areas?

The concept of paludiculture, which first emerged in the 1990s, is a new approach to farming on peat soils. It aims to offer an economically viable option for such land through accelerated peatland rewetting combined with the use of wetland-adapted plant species as commercial crops (Joosten & Timmermann 1999, Joosten *et al.* 2015). Paludiculture can reduce GHG emissions substantially compared to drainage-based conventional agriculture. This is because of the overriding influence of raised water tables on reducing peatland emissions (Evans *et al*. 2021). Reduced peatland emissions and their consequent climate-change benefits are therefore strong motivations for the adoption of paludiculture (Ziegler 2020). Transformation of peatland land management away from conventional agriculture and towards paludiculture offers an increasingly important and potentially attractive means of achieving net zero carbon emissions by 2050 (Chen *et al.* 2024). Increased awareness of the amount of carbon stored in peat soils and the scale of carbon emissions when such soils are disturbed has significantly altered the perception of peatlands within science, government and policy circles (Wichmann & Nordt 2024). Apart from the role of paludiculture in achieving net zero, additional important benefits from peatland rewetting are improved peatland ecosystem services (ES) such as the prevention of physical soil losses, nutrient cycling, reduced flood risk and biodiversity provision (Trenbirth & Dutton 2019).

Agricultural peatlands account for 55 % of cropland emissions in EU, while representing only 4 % of the total area (Duscha *et al.* 2019, Niemi *et al.* 2024). In England, however, lowland peat under agriculture is responsible for 88 % of the country's total emissions from peat soils, amounting to 8.52 Mt of carbon dioxide equivalents annually (Evans *et al*. 2017). Peat wastage (i.e., oxidation) under cropland has the highest GHG emissions of any UK land use on peat (>10 times higher than emissions from upland peat) (Mulholland *et al.* 2020) and represents a physical loss of the soil resource. To support the government's climate ambitions, the Climate Change Committee (CCC) has recommended that 60 % of UK lowland peatlands should be rewetted or be sustainably managed by 2050 (CCC 2020). Within this context, the uptake of paludiculture has the potential to make an important contribution to achieving the UK's commitment to net zero GHG emissions by 2050 by reducing carbon emissions from drained peat soils.

Paludicrop species are diverse, ranging from trees to grasses, mosses, herbs and berry-producing shrubs (Abel *et al.* 2013). Paludiculture crops may offer lower but more reliable economic yields than would be likely for conventional crop species under future climate scenarios, and by protecting the soil from ongoing loss this may also help to maintain the productive lifetime of the peat soil resource (Mulholland *et al.* 2020). Some food (e.g., meat and milk) can still be produced in paludiculture, albeit at a lower level of productivity (currently) than on drained peatlands, but nevertheless with clear environmental advantages over drainage-based peatland management (Tanneberger *et al.* 2021). Paludiculture products have a potentially diverse range of markets including fuel (biomass), fodder, horticultural substrates, construction materials and carbon credits, but given the early stage of paludiculture development these are rarely commercially viable at present (Ziegler *et al.* 2021). The potential overall value of the paludiculture market is currently under-studied and is therefore difficult to quantify. The UK Department of Environment, Farming and Rural Affairs (Defra) has nevertheless produced a 'roadmap' which sets out a ten-year programme of work designed to identify and address gaps as a means of facilitating the development and adoption of paludiculture in the UK (Defra 2023b).

Even though paludiculture enables the land to remain productive and can provide new products that can further reduce GHG emissions (Lahtinen *et al.* 2022), such a radical change in agricultural practice is not yet attractive for the majority of stakeholders (Niemi *et al.* 2024). This article aims to review current paludiculture policies in the UK, examine the barriers to large-scale implementation, and identify the systemic factors needed to enable upscaling.

LITERATURE REVIEW METHODS

A comprehensive search of academic databases and grey literature sources was conducted to review paludiculture policies in the UK. Currently, the UK does not have an overarching paludiculture policy, meaning that responsibility for such policy falls to the devolved governments of England, Wales, Scotland and Northern Ireland. The situation in England was selected as a case study on account of its relatively advanced policy initiatives. These efforts are central to the paludiculture policy landscape in England and are important for understanding the barriers to upscaling in the broader UK context. Barriers to implementation were similarly identified through a

systematic review of academic and grey literature. To further analyse these barriers and assess the systemic needs for scaling up paludiculture, we adapted the capacity pyramid framework developed by Potter & Brough (2004), which was chosen for its effectiveness in addressing complex multi-level challenges in policy implementation.

UK PALUDICULTURE POLICIES

It is likely that paludiculture will eventually be incorporated within the UK's policy framework as a land use option for net zero. However, the existing framework for land use has been described by the CCC as 'not delivering' for climate change. This is largely due to gaps in current policy and voluntary initiatives not performing as expected, as well as a patchy framework of support for farmers and landowners. This combination of factors means that policy and practice do not yet deliver improvements at the pace required to meet the net-zero goal (CCC 2020). More positively, however, the post-Brexit opportunity to redevelop land use policies can be regarded as an opportunity for change.

The England Peat Action Plan (Defra 2021) sets out "an integrated plan for the management, protection and restoration of upland and lowland peatlands, so that they deliver benefits for nature and the climate". It embraces a range of broad and peatland-specific policies, with delivery mechanisms split between peatland habitat restoration and paludiculture. It progresses peatland restoration and paludiculture aims by setting targets for both of these land use options; and the two delivery mechanisms converge within ELMS and the Countryside Stewardship scheme (Figure 1). The delivery mechanisms are additionally relevant to multiple policy areas beyond peat soils - such as decarbonisation, energy, land use, water management and construction. Although the significant overlap between the Action Plan's delivery mechanisms

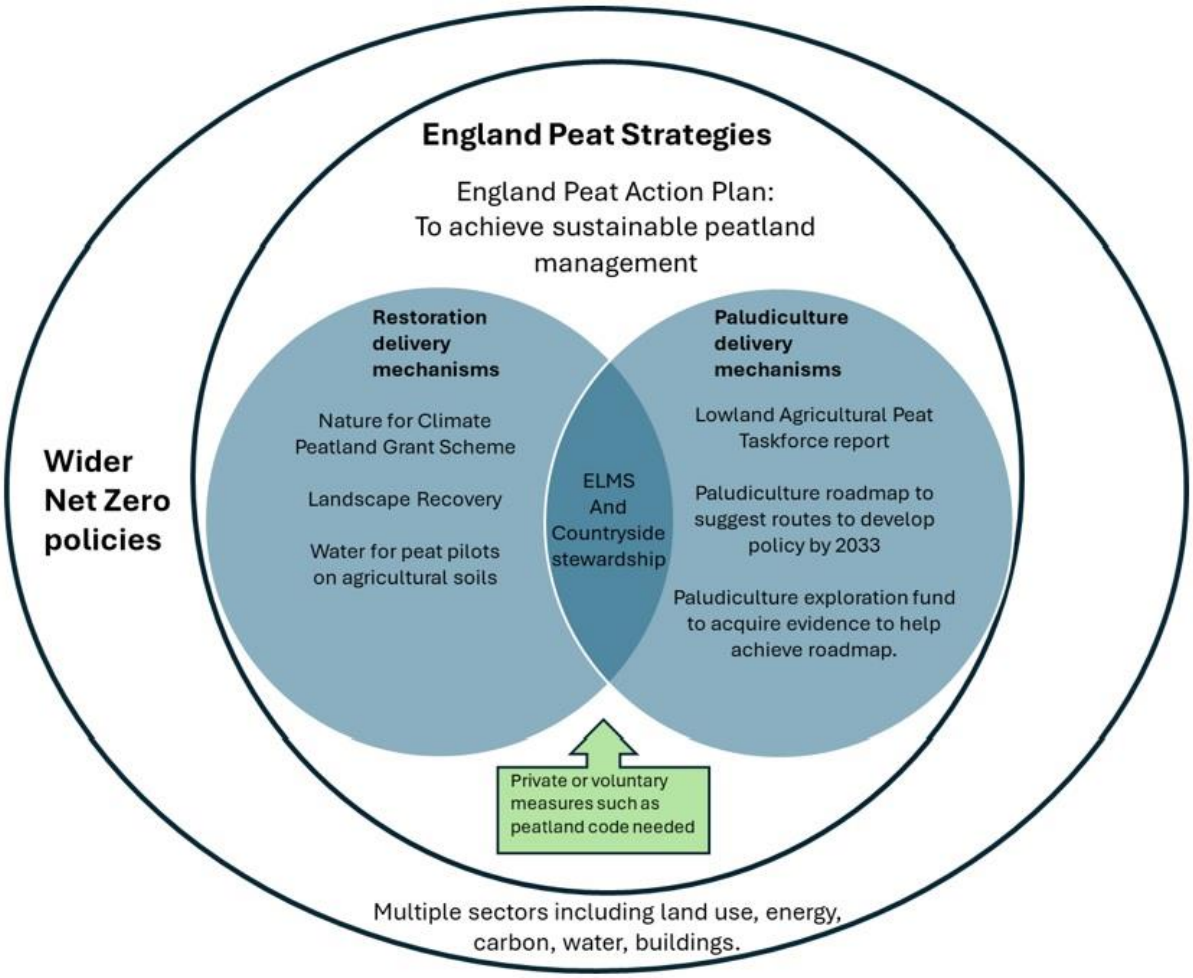

Figure 1. The policy context for paludiculture in England, and its overlap with restoration in terms of delivery mechanisms. Source: Authors' own synthesis based on reviewed academic and grey literature.

offers potential for its implementation to achieve both peatland restoration and paludiculture, it is likely that blended private finance and voluntary inputs - such as the Peatland Code currently run by the IUCN UK Peatland Programme - may also be needed to act as external drivers of peatland land-use change.

England has been the most active of the devolved UK countries in driving paludiculture-related policy development through various activities organised by Defra. Key developmental activities to date are outlined below.

- The England Lowland Peat Strategy aims to promote sustainable management of England's peat resource and deliver aspects of the UK peatland strategy. Its highlights include the phasing out of peat use and demand for horticulture, driving the restoration of 35,000 ha of peatland via the Nature for Climate Peatland Grant Scheme, and developing commercially viable paludiculture. The 2021 England Peat Action Plan aims to ensure responsible management of all peatlands, including deep and protected sites, and sets a target for peatland restoration as part of the Net Zero Strategy. Key aims include managing all soils sustainably by 2030, bringing 75 % of Sites of Special Scientific Interest into favourable condition by 2042, developing a Nature Recovery Network, and publishing an implementation plan with five-year targets.
- The competitive Nature for Climate Peatland Grant Scheme was a peatland-specific initiative administered by Natural England. This provided short-term public grants that fully funded several small-scale peatland restorations in England from 2021 to 2025. One example is The Norfolk Broads Peat Discovery Project, which delivered farmer engagement sessions on paludiculture (Broads Authority 2025).
- The Landscape Recovery Scheme (see Figure 1) was developed within the ELMS to provide (much) longer-term habitat restoration and was not exclusive to peatland habitats. Projects typically delivered a co-designed agreement between landowners, NGOs and communities, to support restoration over 20+ years. Landscape recovery was financed via a blend of public and private funding. An example project with a paludiculture element is The Greater Sedgemoor Landscape Recovery Project (RSPB 2025)
- Following the 14 recommendations for sustainable use of agricultural peatland soils made by the LAPTF, some action plans were taken forward. For example, to deliver Recommendation 2, two Water for Peat pilot schemes were announced. The Lowland Agricultural Peat Water Discovery Pilot (LAPWDP) grant (2023) was designed to improve landowners' and other organisations' understanding of how water can be better managed to rewet and preserve peat soils through the adoption of wetter farming ('wetter farming' is being used in the community as a broad term that includes farming with higher water levels, using traditional or paludicultural crops). Following Recommendation 14, a ten-year policy roadmap for England has been created, which aims to encourage the uptake of economically viable paludiculture based on a variety of the most developed paludiculture crops starting from 2023. This gives detailed directions on the stages which need to be completed to implement paludiculture, facilitating future actions to overcome barriers and provide evidence for policy development (Defra 2023b).

Other organisations have been encouraged by Defra to engage in evidence-provision activities; for example, the £5 million Paludiculture Exploration Fund (PEF) is managed and delivered by Natural England. The PEF seeks to develop the evidence base through research as well as unlock barriers to making commercial paludiculture a reality (Milner & Champ 2022). It has financed 12 projects looking at a range of plants, products and production opportunities with a view to broadening the evidence base for paludiculture.

Thus, paludiculture is expanding rapidly in the UK. More detail on current PEF projects and other activities of the wider UK paludiculture community can be found on the UK 'Paludiculture' website at https://www.paludiculture.org.uk/.

BARRIERS TO PALUDICULTURE IN THE UK

Cultural legacy and status quo

Land use is both a cultural and a political issue. Prevailing mindsets, drivers and perceptions may influence the attitudes of stakeholders to changes in land management techniques (Pusvita *et al*. 2024). Cultural backgrounds combined with the novel technical aspects of paludiculture inevitably make the implementation of change difficult, particularly as land drainage has been a key driver of agricultural practice for hundreds of years and reversal of this practice is fundamental to paludiculture. Land conversion for agriculture through drainage of peat soils intensified as early as the 17th century (Darby 1956, Sheail & Wells 1983), resulting in the high agricultural productivity which has been maintained

to this day. For example, the East Anglian fenland provides more than 7 % of England's total agricultural production, worth £1.23 billion; with the whole food chain, from farm to fork, employing 80,000 people and generating more than £3 billion a year for the regional economy (NFU 2019). However, this has an environmental cost in terms of soil health, soil losses and carbon emissions.

The long cultural history of peatland drainage has shaped perceptions and attitudes towards agricultural use of peatlands in that their drainage for food production and other drainage-based land uses has been endorsed as a cultural achievement over centuries (Strutt 1970, Soffe 1995, Ziegler *et al.* 2021), whereas wet peatlands are seen as unproductive. The close association between drainage and high productivity is, therefore, deeply rooted in the mindsets of stakeholders such as farmers and landowners, and this cultural legacy is likely to have influenced the historical and current policy and legal framework. There are also further reactionary perceptions and cultural mindsets; for example, wetland rewetting is perceived to increase flood risk (Hambäck *et al.* 2023).

Immature policy framework and the absence of economic incentives to support paludiculture

The cultural legacy of peatland drainage is partly why, until recently, the EU's legislative framework for agriculture did not explicitly support and, indeed, often actively opposed paludiculture plans and paludicrops (Geurts *et al*. 2019). A recent exploration of the potential for implementation of paludiculture in Germany concluded that the main obstacles are the ongoing support of conventional drainage-based peatland use and the absence of economic incentives for converting to paludiculture (Schäfer *et al.* 2021). The current form of the EU's Common Agricultural Policy (CAP) also supports conventional crops produced via drainage-based agriculture (Wichmann 2018). Originally, subsidies under the CAP were available for only drainage-based use of peatlands, meaning the implementation of paludiculture incurred a risk of losing them (Wichmann & Nordt 2024). However, the CAP revisions of 2023–2027 changed this policy by incorporating paludiculture into productive agricultural land use, so the subsidies may now be directed to paludiculture (Niemi *et al.* 2024). This is a route that the UK nations could potentially follow.

Clashes and lack of coherence between agricultural and climate policies are also seen in the UK. Agricultural development on peat soils provides an example of a policy clash because conventional agriculture is amongst the most-common uses of lowland peatlands and benefits significantly from government agricultural support as well as infrastructural support through government bodies such as the Environment Agency. It is estimated that 7 % of the UK's total peatland area is being used as cropland, which results in emissions of 7.6 million tonnes of CO_2 per year, representing 32 % of all GHG emissions from peatlands in the UK (Evans *et al.* 2017). This means that government-supported agriculture on peatlands is currently hindering government efforts to achieve net zero and meet international obligations in terms of the UK's Nationally Determined Contributions (NDCs) under the Paris Agreement. Agriculture in the form of paludiculture could instead contribute to reducing agricultural GHG emissions whilst also offering farmers of land with peat soils an economically viable way forward.

One example where certain policy clashes have been overcome is the redevelopment of the Countryside Stewardship (CS) scheme for 2025. This introduces subsidies that could be utilised to implement paludiculture and reduce GHG emissions by incentivising new water table management regimes. These subsidies will be available for cropped and arable land with lowland peat soils (CSW17 and CSW19) as well as permanent grassland on lowland peat soils (CSW18 and CSW20). Each land use has two payment tiers depending on water table depth (31–50 cm or 10–30 cm below the ground surface), and this water table range must be maintained all year round. The subsidy payments range from £840 ha^{-1} to £1409 ha^{-1} (Rural Payments Agency 2024). The lower-rate scheme offers a stepping stone to the higher one, although both schemes will lead to carbon emission reductions. The high water table incentives CSW17 and CSW18 offer the greatest incentives for adoption of paludiculture by facilitating rewetting, although they do not make specific recommendations or provisions paludicrops. Adjustments to these incentives and capital offers may also be developed as part of CS in the future.

Knowledge barriers to uptake of paludiculture

An additional barrier to the adoption of paludiculture is lack of knowledge about the societal burden that drained peatland use imposes on climate, water and people (Ziegler *et al.* 2021), as well as lack of knowledge about paludiculture and its benefits. For a recent study in Sweden aiming to explore the influence of paludiculture on farmers' livelihoods, 25 key stakeholders were interviewed. There was an evident lack of knowledge about paludiculture as even the term 'paludiculture' was not recognised by

farmers, nor was there any knowledge of rewetting organisation in Sweden (Klooster 2023). Also in 2023, Manchester Metropolitan University and the University of Galway conducted surveys with 19 farmers on their attitudes towards wetland farming (paludiculture) in England (UK) and Ireland. In both countries, most of the farmers interviewed had not heard of paludiculture (Care-Peat 2023). Defra (2024) delivered research exploring farmers' attitudes towards their peat soils in lowland agricultural regions in England through 30 interviews. Their results show that, to the farmers, "peat improvement" meant increasing the financial value of the soil by keeping it drained to grow crops or to graze animals; and many farmers were shocked by the idea of raising water tables. Overcoming these cultural and knowledge barriers and changing stakeholder perceptions cannot be achieved without improving knowledge and transforming values and relationships (Wichmann & Nordt 2024).

Economic uncertainties and the potential for paludiculture markets

Paludiculture also faces the challenge of under-developed products and markets. This is a crucial issue that needs to be overcome to convince stakeholders, especially farmers. The potential paludicrop common reed is used as a traditional roofing material across Europe. The major reed-consuming countries in western Europe (The Netherlands, Germany, UK and Denmark) all rely on imports from eastern and southern Europe and China because the current area of reed-producing wetland in western Europe is insufficient to meet demand (Wichmann 2021). In China, paludiculture has long been established as a cultivation method for reed to be used in paper production in areas where wood pulp is in short supply (Wichtmann *et al.* 2016).

The UK Paludiculture Live List identifies around 88 native species as candidates for wetter farming, with possible uses for energy, food, fodder, medicine and building materials (Defra 2023b). Table 1 shows some examples of potential uses of paludicrops in the UK (Abel & Kallweit 2022). There is, however, a 'chicken and egg' challenge to be overcome, because farmers will not cultivate new species unless there is an economic market for the crop, while new markets will not be created around a novel crop until a robust supply chain exists for that crop. New plants from paludiculture require new markets, but these are currently missing in the UK. Common reed for thatching is the only paludicrop that currently has an established market in the UK. However, 95 % of the UK demand for thatching reed is currently imported because reed production areas in the UK are so limited (Milner & Stuart 2022). This points to a real opportunity for UK paludiculture. Other paludicrops such as *Sphagnum* moss and *Typha latifolia* also have considerable potential in the UK markets for horticultural growing media and building materials.

In a profitability analysis of *Typha* versus dairy farming in The Netherlands, *Typha* farming was evaluated as offering economic benefits of €150 ha^{-1}, but high production costs at the pilot scale made the net profit slightly negative overall, at €-5 ha^{-1}, which compared poorly with the net profit of €1035 ha^{-1} from dairy farming (de Jong *et al.* 2021). An increase in price or a decrease in costs for *Typha* could tip the balance in this case. Economic assessments of paludiculture based on pilot studies are hampered by the limited size of these pilot studies, whereas the larger-scale farms of the future would benefit from

Table 1. Examples of paludiculture crops that have potential for use in the UK. Adapted from Defra (2023b).

Sector	Paludicrops
Food	bilberry, celery, cheese, cranberry, meat, nettle, sedge grains, sweet grass grains, watercress, water pepper
Herbal remedies, and biomedical	bilberry, bog myrtle, cranberry, comfrey, hemp agrimony, lady's smock, meadowsweet, round leaved sundew, *Sphagnum* moss
Construction materials	fibreboards - *Typha* and reed, lightweight aggregates - *Typha,* roofing (thatch) - reed
Bioenergy	*Typha*, reed, willow
Growing media	*Sphagnum* moss
Fabric	*Typha* seed heads (down replacement), nettle

increased economies of scale, meaning that commercial paludiculture could be expected to have a higher profitability than indicated by current small-scale pilot studies. Beyond improved economies of scale, it is likely that additional enablers will be required to increase the economic competitiveness of paludiculture. Such measures could include policy incentives such as environmental payments through ELMS or, alternatively or together with, subsidies, levies or taxes on the current land use. Innovations in harvesting machinery and techniques should also improve efficiency and profitability (Wichmann *et al.* 2017). To make the case for change, it is likely that the profitability of paludiculture will have to exceed the current status quo if it is to balance the risk surrounding adoption of such a new and, for many farmers, radical practice.

The market potential for paludiculture has already been studied in several European countries. In 2023, the consultancy company 'Systain' performed a feasibility study for paludicrops in six market sectors in Germany (paper, building materials, wood, plastics & chemicals, cat litter, bioenergy) via 40 interviews with companies (Wichmann & Nordt 2024). The study found that paludiculture materials offer dual benefits by reducing GHG emissions through their production and displacing the fossil-fuel-based materials that are currently used. In addition, the study suggested that changing the policy and regulatory environment encouraged decarbonisation and increased future opportunities for paludiculture products. Routes to scalability were also explored. The authors suggested that cross-sectoral knowledge transfer could be achieved through outreach activities such as demonstrations of a 'paludi tiny house', while innovation stimulus would also be important in the value chains that were explored (Systain 2023).

In addition to overcoming the uncertainties associated with novel market products, economic concerns need to be addressed by developing the paludiculture evidence base. For example, landowners may be cautious about transitioning to paludiculture where transaction costs and future revenues are likely to be uncertain, at least initially (Garrett 2023). Some farmers may accept wetter farming as a desirable concept but express their concerns about investment risks, the economic viability of paludiculture and a loss of land value (Wichmann & Nordt 2024). This has frequently been mentioned by farmers in the UK because they perceive rewetting as risky due to its high initial capital costs combined with uncertain future return on investment from government schemes or crop sales (Defra 2024). A requirement for new ways of using harvesting machinery is likely to dictate adaptation of existing assets to manage the wetter soils, or the purchase of new low-ground-pressure vehicles. All of this poses additional financial risks. Such barriers could be overcome through specialist contractor firms or cooperative farming models, but these may need facilitation for both early-adopter farmers and the contractors themselves (Schröder *et al.* 2015, Wichmann 2021).

FROM POLICY TO PRACTICE: CAPACITY BUILDING FOR THE ADOPTION OF PALUDICULTURE

Paludiculture is developing rapidly as a policy concept, but its evidence base is still limited. Strengthening this foundation by providing evidence is essential to support widespread uptake. To visualise the interconnected elements of effective interventions, we have adapted the capacity pyramid developed by Potter & Brough (2004) to address how to overcome the barriers to paludiculture mentioned in the previous section. The capacity pyramid is a generalised problem-solving framework for eradicating the underlying challenges in various sectors.

In our adaptation (Figure 2), we have integrated the 14 recommendations of the LAPTF alongside the England Paludiculture Policy Roadmap. Reflecting both, the capacity pyramid is a series of interventions that must be understood as a system. Based on the capacity pyramid, large scale implementation of paludiculture requires government interventions across all layers of the pyramid from fundamental policy formulation to upper-level mechanisms such as equipment provision.

More importantly, addressing the foundational levels such as the coherence between climate-change and agricultural policies is a precondition for successful implementation of interventions higher in the pyramid such as delivering incentives, advice support, knowledge transfer and machinery provision. This systems-based framework also offers researchers a structured model for refining individual components through more granular investigation.

Institutional and organisational capacity

If paludiculture is to be adopted at scale, policy coherence - particularly between climate-change and agricultural frameworks - is vital. Current legal and institutional frameworks must be revised to minimise incentives that maintain or stimulate peatland drainage. At the same time, new financial mechanisms must be introduced including public sector incentives such as

payments for ecosystem services (PES) and the development of recognised carbon market standards tailored to paludiculture practices.

Paludiculture also offers an enhanced range of peatland ecosystem services such as biodiversity provision, nutrient cycling and water treatment or regulation, and the way in which these are employed within any policy or support system will be important (Vroom *et al.* 2018). However, many of these benefits remain under-quantified, and are not yet fully reflected in agri-environmental subsidy schemes or frameworks for public goods delivery. Urgent work is needed to quantify these benefits and incorporate them within subsidy schemes for the provision of public goods.

Incentives must also extend beyond the farm to cover further steps along the supply chain. This includes crop processing, end-product manufacturing and market development (Schäfer *et al.* 2021). It is necessary to diversify the types of stakeholders who provide funding for paludiculture, ensuring that there is a transition to a blend of public and private finance over time rather than relying on perpetual government funding.

Paludiculture offers additional opportunities for integration into broader land-based strategies such as water resource and renewable energy planning to secure financial support. One model is the 'Water Fund for Carbon,' which is an independently governed long-term financial model operated by water companies. In addition, paludiculture-energy systems could co-locate with PV arrays or wind turbines (Tanneberger *et al.* 2021, Pollybell Farm 2020) or contribute to off-site bioenergy production (Wichtmann *et al.* 2016). Paludiculture can also reduce building sector emissions (11 % of global GHG emissions) through the use of bio-based building materials with lower embedded carbon and enhanced thermal performance (Güneralp *et al.* 2017, de Jong *et al.* 2021).

Human capacity

As discussed in the previous section, the awareness and knowledge of stakeholders remain limited. Farmers have little knowledge of paludiculture, paludicrops and associated practices. However, they often trust in the experience of other farmers and advisors. Expanding the availability of accessible practical information is critical, with demonstration sites and advisory services playing a key role (Wichmann 2018). To support this transition, governments should fund advisory services (Wichmann & Nordt 2024) and invest in 'farmer champion' models, which are peer-to-peer networks that have proven effective in disseminating new agricultural practices (Turner *et al.* 2021). These initiatives should focus on both scaling up and disseminating knowledge.

At the same time, research is needed to explore UK farmers' perceptions of wetter farming and their willingness to adopt paludiculture. Existing evidence is limited and mostly based on literature review. Social research is therefore needed to understand whether farmers might be willing to adopt paludiculture as part of their businesses and, if so, what obstacles they currently face in implementing the paludiculture model in the UK.

As suggested by the Paludiculture Roadmap, capacity building amongst stakeholders needs to be inclusive, targeting funders, bankers, investors and policy makers. Ensuring that all stakeholders are engaged will help to drive innovation across the entire paludiculture landscape and at all stages of the future value chains.

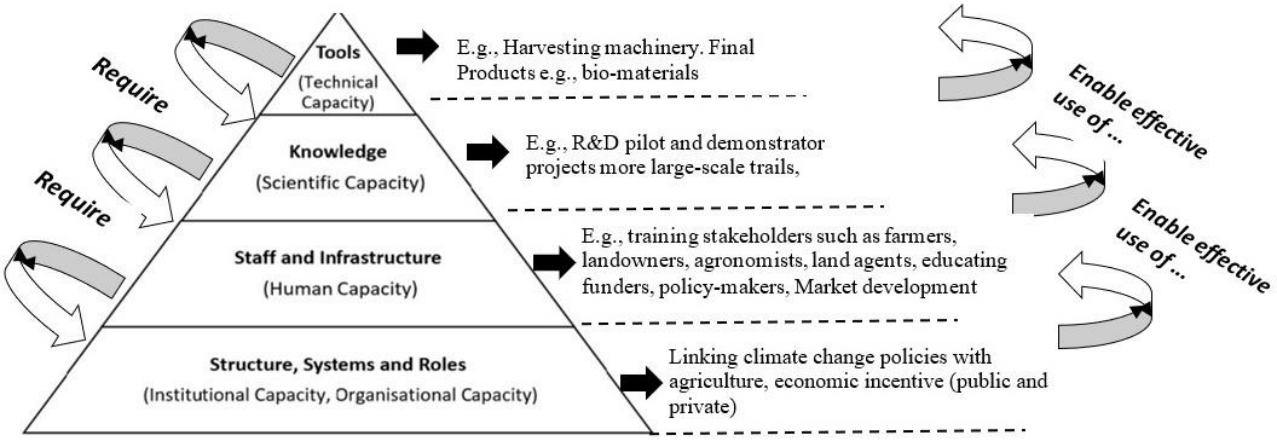

Figure 2. Paludiculture capacity building. Adapted from Potter & Brough (2004) and Khosravi *et al*. (2024).

Scientific capacity

Pilot projects are key to building the evidence base for paludiculture and fostering knowledge exchange across stakeholder groups. To be effective, pilot projects must involve close communication with, and dissemination of project results to, stakeholders such as farmers, scientists, practitioners, authorities and consultants.

These projects must target a broad range of issues from GHG measurements and ecosystem services to laboratory testing of crop materials and market research for specific crops. Pilot projects of this kind have already been initiated at a small scale in England, for example through the Lowland Agricultural Peat Small Infrastructure Pilot and the Lowland Agricultural Peat Water Discovery Pilot. Whilst these are a useful starting point, they require significant expansion.

Pilot projects must be designed to collaborate closely with stakeholders, especially farmers, to ensure the research outcomes are grounded in practical realities. A useful example is the Dutch pilot aiming to introduce the cultivation of wet crops on peat meadows to dairy farmers, enabling them to evaluate the possibilities of paludiculture crops in their own environment and possibly on their own farms (Geurts & Fritz 2018).

Technical capacity

Transitioning to paludiculture will require new approaches to harvesting machinery and this will involve adapting existing equipment for wet soils or investing in low ground pressure vehicles. Sectoral engagement is also needed, especially with the building industry and materials scientists, to showcase the benefits of paludicrop-based biomaterials such as low embedded carbon and improved insulation. Such collaborations can influence market perceptions and help align construction sector practice with national decarbonisation goals.

Paludiculture market development

Market development for paludiculture is a cross-cutting issue that both shapes and is shaped by multiple layers of the capacity-building framework. While governments need to create the right policies, subsidies and financial incentives to enable paludiculture (i.e., build institutional capacity), this alone is insufficient. Importantly, paludiculture crops require new markets that are currently missing (Wichtmann *et al*. 2016, Niemi *et al.* 2024). Without viable end markets, the shift from conventional agriculture is unlikely to appeal to farmers (one target of stakeholder capacity-building). The combination of emerging markets and appropriate subsidy schemes must be a strong enough incentive to persuade landowners and farmers to adopt wetland cropping. Policy instruments can enable development of the paludicrops market in different ways, e.g., by phasing out insulation materials based on fossil fuels and providing a subsidy for bio-insulation materials (de Jong *et al.* 2021), or by introducing product-based incentives. The creation of an active market is essential to assessing the real-world economic feasibility of paludiculture, as current assessments are largely based on theoretical projections.

CONCLUSIONS

Although paludiculture is a key means of contributing to climate change mitigation while allowing farmers to keep the land productive, implementation currently falls far short of potential due to a wide range of cultural, knowledge, market and policy barriers. Such a radical change in land use is both a cultural and a political issue and therefore needs an integrated approach encompassing research, development and policy reform.

Successful implementation of paludiculture across the UK requires agricultural policies and payment schemes (e.g. ELMS-related schemes) to set explicit and real incentives for paludiculture. These schemes should be developed as coordinated support mechanisms across multiple sectors and be designed to avoid policy conflict and the creation of new perverse incentives.

Paludiculture markets and products are still in their early stages in the UK and are unlikely to mature on a meaningful timescale without parallel industry-focused incentive schemes. However, advancing this policy depends on the development of a more robust evidence base. Since paludiculture is an emerging land use with crops and products at different levels of commercial readiness, widening the evidence base is essential. This will give policymakers the confidence to integrate paludiculture into the existing policy framework or design new policies to support uptake.

Evidence-provision activities such as those led by the PEF can play a critical role in accelerating this policy adaptation. To be effective in this role, the scale and scope of the PEF must be increased to support a broader range of pilot projects, data collection and knowledge-sharing initiatives across regions and sectors. All layers of the capacity pyramid must be addressed, from policy reform and financial incentives to enabling infrastructure and market development, to position paludiculture as a viable, scalable and integral part of UK agriculture and land use.

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AUTHOR CONTRIBUTIONS

FK: conceptualisation, methodology, writing original draft, writing review; JAC: conceptualisation, writing, review and editing; RAL: writing review and editing, funding acquisition.

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